Elemental Diet for Nutritional Support in Gastrointestinal Surgery

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Elemental Diet for Nutritional Support in Gastrointestinal Surgery

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Summary

Clinical usefulness of elemental diet (ED) in tube feeding after GI surgery and in preoperative preparation of colonic surgery, changes of plasma gut hormones under tube feeding and experimental studies on changes of intestinal microflora under long-term administration of ED in rats were examined.

The results obtained are as follows : 1. Complications following tube feeding appeared in about 70% of the patients, in whom some nutritional parameters deteriorated slightly. 2. Plasma levels of enteroglucagon (EG) and neurotensin (NT) significantly increased after start of enteral feeding. 3. Colonic preparation using ED was poor in 19% of patients with clinical symptoms of stenosis and 31% of patients whose index of stenosis showed more than 50%. 4. Intestinal microflora was deranged and the ratio of anaerobes to aerobes increased as compared with that of preadministration.

ED was useful for the nutritional support in upper GI surgery and preoperative bowel preparation. However, intestinal bacterial colonies might alter by long-term administration of ED.

Introduction

Total parenteral nutrition (TPN), in which Dudrick[8] plays an important role in the development of nutritional method before and after gastrointestinal surgery, has exerted dramatic effects on the treatment of various diseases, and contributed to the rapid development of nutritional therapy. On the other hand, traditional enteral feeding, reconfirmed by the development[10,25] of an elemental diet (ED), and proven as effective as TPN, has been developed as an enteral hyperalimentation[15]. In Japan, ED was devised in 1978 and Elental® (Morishita Pharmaceutical Co. Ltd.,) was marketed first in 1981[19], mostly for gastrointestinal surgery[18]. Recent

Key words: Elemental diet, Enteral hyperalimentation, Gut hormone, Preoperative bowel preparation, Intestinal microflora.
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utilization of ED includes other fields of medicine as well. This paper reports our clinical applications of ED to enteral feeding after upper GI surgery and its effects on some gut hormones, to preoperative bowel preparation for colonic surgery, and experimental results of the effects of long-term administration of ED on intestinal microflora in rats.

Materials and Methods

1. Clinical study on enteral feeding:

The subjects consisted of 297 cases in which enteral feeding was undertaken at the Department of Gastroenterological Surgery, Wakayama Medical College, from January 1977 to December 1982. Among these, 185 were patients with stomach cancer and 135 underwent total gastrectomy: 46 had esophageal cancer; and 38 underwent radical esophagectomy. In one hundred and fifty-three patients out of 297, complications caused by enteral feeding, and its treatments, and changes in nutritional parameters, serum total protein (TP) and serum albumin (Alb) or liver function tests were examined retrospectively.

2. Enteral feeding and its effects on gut hormones:

In 35 patients who underwent enteral hyperalimentation, blood was collected 30 minutes before the start. The plasma levels of EG, NT and vasoactive intestinal polypeptide (VIP) were determined by radioimmunoassay. EG was expressed as the difference between total glucagon and pancreatic glucagon.

3. Preoperative bowel preparation for colonic surgery:

Modified ED[1] (mED), mainly consisting of ED, was prepared and orally administered to 97 patients with cancer of the colon. Basically, 2000 kcal/day of mED were administered for 4 days till the night before the operation. Bowel preparation was assessed as good when no feces were found in the colonic lumen. Clinical symptoms of stenosis, administration period, sites of lesions, index of stenosis were analysed in these patients. The relationship between the index of stenosis and colonic preparation was retrospectively studied.

4. Changes of microflora in the gastrointestinal tract following long-term administration of ED:

Rats were fed on ED for 3 months and changes of microflora in the gastrointestinal tract were examined. Microflora in 1 g of material found at each site of the gastrointestinal tract were identified and assayed according to the method of MITSUOKA[17]. Effects of long-term administration of ED on prothrombin time i.e., its effects on vitamin K were then examined using 4 groups: a control group with standard rat chow; an ED group with ED administration; a group administered ED containing a 2-fold quantity of vitamin K; and a group administered ED containing a 10-fold quantity of vitamin K.

Results

1. Clinical study on enteral feeding:

Table 1 shows our administration schedule. We started tube feeding with a low concentra-

Table 1. Our schedule for enteral feeding

	Concentration (kcal/ml)	Volume (ml/day)	Energy (kcal/day)
1 ED	0.25	600	150
2 ED	0.50	600	300
3 ED	0.75	810	600
4 ED	1.0	900	900
5 ED	1.0	1200	1200
6 ED	1.0	1500	1500
7 ED	1.0	1800	1800
8 ED	1.0	2000	2000
(5) LRD	1.0	1200	1200
(6) LRD	1.0	1500	1500
(7) LRD	1.0	1800	1800
(8) LRD	1.0	2000	2000

ED: elemental diet, LRD: low residue diet

tion of ED. Its volume and calories were then gradually increased in order to maintain with low residue diet (LRD), while the doses were set at 3 times daily. In most cases, tube feeding was started on the fourth or fifth day after operation, and continued for 6–15 days in 94 cases. In patients with anastomotic leak, tube feeding was continued for more than 30 days, and the longest administration period was as long as 228 days. Clinical complications accompanying enteral feeding appeared in 107 out of 153 (69.9%). Incidence of abnormal bowel movement, such as diarrhea, was as high as 61.4% and withdrawal rate of enteral feeding as a result of these symptoms was rather high (8.5%) (Table 2). In term of the treatment of abnormal bowel movement, use of natural aluminium silicate and albumin tannate, or powdered ginseng laudanum was effective. In cases having complications, serum Alb was reduced significantly at the time when enteral feeding ended ($p<0.01$), and S-GOT and S-GPT increased significantly, though remaining in the normal range ($p<0.01$). However, in the cases without complications, no significant

Table 2. Complications following enternal feeding

	No. of cases	Per cent
Abnormal bowel movement	94	61.4
Sense of fullness	12	7.8
Abdominal pain	10	6.5
Trouble of feeding tube	6	3.9
Nausea	5	3.3
Obstruction of feeding tube	4	2.6
Vomiting	2	1.3
Sweating	2	1.3
Intussusception	1	0.7
General fatigue	1	0.7
Gargling sound	1	0.7
Fever	1	0.7

Table 3. Changes of nutritional parameters in patients with or without complications

		Complications (n=98)			No complications (n=44)		
		Before	After		Before	After	
Total protein	(g/dl)	6.9±0.6	6.9±0.7	N.S.	6.9±0.5	6.9±0.8	N.S.
Albumine	(g/dl)	3.9±0.4	3.7±0.6	p<0.01	3.7±0.5	4.0±0.5	N.S.
GOT	(I.U.)	20±14	29±16	p<0.01	22±19	28±17	N.S.
GPT	(I.U.)	22±20	32±19	p<0.01	20±12	27±17	N.S.

Mean±SD

differences were observed and figures remained in the normal range before and after enteral feeding (Table 3.).

2. The effects of enteral feeding on gut hormones:

Plasma level of each gut hormone before and after ED administration is shown in Table 4. After the administration, EG and NT increased 3.8 fold and 2.7 fold ($p<0.05$), respectively. No significant changes, however, were observed on VIP In correlation with the presence of diarrhea during enteral feeding and various hormone values, EG increased to 1.7 fold in the groups having diarrhea ($p<0.05$); no significant differences were observed in NT and VIP (Table 5).

3. Preoperative bowel preparation for colonic surgery:

Good results were obtained in 85 cases out of 97(87.6%). 44 out of 54 cases having symptoms caused by colonic stenosis due to the lesion (81.5%), 41 out of 43 having no symptoms caused by stenosis (95.3%). Among 12 cases with poor results, 10 (18.5%) had symptoms caused by stenosis (Table 6). In terms of administration period, good results were obtained in 51 cases out of 61 (83.6%) with a 4 day administration, 26 out of 28 (92.8%) with a 7 day administration, and all the cases with administration for 8 days or longer. In terms of sites of lesions, poor results were seen in 3 cases with sigmoid colon cancer and 9 cases with rectal cancer; in total 12 cases (12.4%). According to the index of stenosis which was calculated from the finding of preoperat-

Table 4. Plasma levels of gut hormones before and after enteral feeding

	Before (n=9)	After (n=8)	
EG	126.8±91.0	478.7±413.3	p<0.05
NT	15.6±14.2	41.9±32.8	p<0.05
VIP	11.3±6.2	19.8±24.2	N.S.

Mean±SD, (pg/ml)

Table 5. Plasma levels of gut hormones of patients with or without diarrhea

	Diarrhea (n=5)	No diarrhea (n=9)	
EG	218.0±36.3	126.8±91.0	p<0.05
NT	10.8±7.4	15.6±14.2	N.S.
VIP	10.5±5.6	11.3±6.2	N.S.

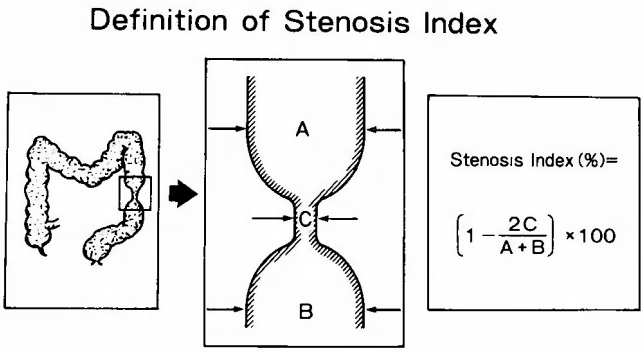
Mean±SD, (pg/ml)

Table 6. Assessment of colonic preparation by clinical symptoms of stenosis

	Symptom (n=54)	No symptom (n=43)
Good (no residue)	44(81.5%)	41(95.3%)
Poor (gross residue)	10(18.5%)	2(4.7%)

Table 7. Relation of index of stenosis to assessment of colonic preparation

	Index of stenosis		
	>76%	50-75%	<49%
	n=41	n=35	n=21
Good	33 (80.5%)	31 (88.6%)	21 (100 %)
Poor	8 (19.5%)	4 (11.4%)	0



ive barium enema, 8 cases out of 41 (19.5%) with more than 76%, 4 cases out of 35 (11.4%) with 50–75% and no cases with less than 49%, showed poor results. As a result of attempting to assess how index of stenosis of the colon or rectum, caused by lesions, relates to administration period,

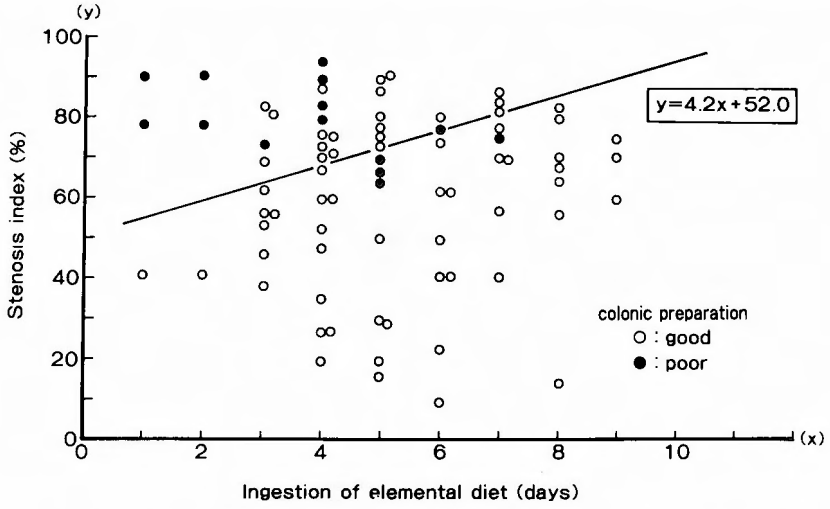


Fig. 1. Correlation between stenosis index and ingestion period of elemental diet in colonic preparation

Table 8. Ghanges of GI microflorain rats before and after administration of ED

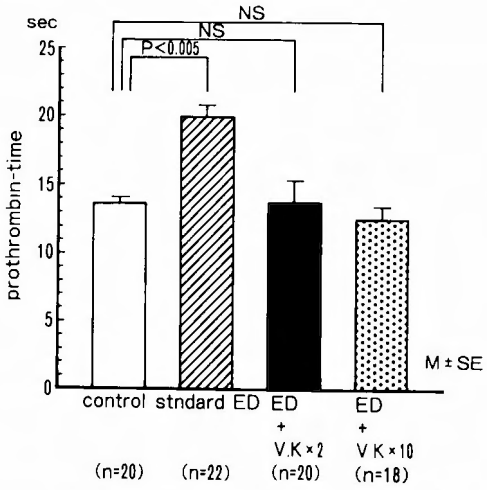
	Stomach	Upper intestine	Lower intestine	Cecum	Colon
Anaerobes					
Bacteroidaceae	NS	⑪	⑪	⑪	NS
Bifidobacterium	↓↓	NS	NS	↓	↓
Vellionella	NS	⑪	⑪	NS	NS
Clostridium	NS	①	⑪	⑪	⑪
Aerobes					
Lactobacillus	↓↓↓	↓	↓↓	↓	↓↓↓
Enterobacteriaceae	↓↓↓	NS	NS	↓	↓
Streptococcus	↓↓↓	NS	NS	NS	↓
Staphylococcus	↓↓	NS	NS	NS	↓↓
Pseudomonas	NS	NS	NS	↓	↓↓↓
Anerobes/Aerobes	①	⑪	⑪	⑪	⑪
Total bacteria	↓↓↓	↓	↓↓	⑪	NS

NS: not significant, ①; slight increase, ⑪; moderate increase, ⑪; remarkable increase, ↓: slight decrease, ↓↓; moderate increase, ↓↓↓; remarkable decrease

good and poor preparation group could be distinguished with a linear discriminant function of $y=4.2x+52$: expressing index of stenosis as y; adminis tration period as x (Table 7, Figure 1).

4. Changes in microflora in the gastrointestinal tract following long-term administration of ED:

With ED administration, the total colony number decreased in the stomach and the upper and lower small intestines, and increased in the cecum, but the number did not change in the colon. Generally, major anaerobes, except Bifidobacterium, increased, and a remarkable increase of Bacteroidaceae and Clostridium was noted. On the other hand, colony number of major



standard ED contains 11 μg of vitamine K in 100 g of ED

Fig. 2. Effects of ED or V.K1 rich ED on prothrombin time

aerobes decreased and even the most predominant species, Lactobacillus, decreased at all sites. Thus, the ratio of anaerobes to aerobes colony numbers rose in each site of the gastrointestinal tract, causing marked changes in microflora (Table 8). In the ED group with changes in microflora, prothrombin time was prolonged and bleeding from the pancreas, urinary bladder, etc. was observed. However, in the ED group with additional vitamin K, prothrombin time was not prolonged (Figure 2).

Discussion

1. Enteral feeding

Postoperative nutritional support is important and we have selected enteral feeding as a nutritional method after upper gastrointestinal surgery especially after radical operation for esophageal or gastric cancers. Mode of digestion and absorption of each element of ED in the intestine has yet to be clarified. Since some dipeptides and oligopeptides were reported to be more rapidly absorbed than free amino acids[12,21], enteral feeding agents using these substances have been developed, leading to enteral feeding's greater clinical contribution.

In the traditional method of feeding, gastrointestinal symptoms such as nausea, vomiting, abdominal pain, etc. occurred frequently depending on dose, infusion speed, concentration or infusion site, and, in some cases, administration was discontinued before sufficient qnuatities could be administered. However, with the appearance of ED, the incidence of gastrointestinal symptoms decreased. Since infusion speed is important for preventing diarrhea, we kept less than 100 ml/h. When powdered ginseng was added at the end of infusion to prevent diarrhea and atrophy of villi of intestinal mucosa, incidence of diarrhea was markedly reduced. We tried enteral feeding after upper gastrointestinal surgery as a transitional measure from intravenous feeding to oral feeding[2].

Changes of serum level of gut hormones at the time of enteral feeding were examined. Secretory cells of EG are reported to be scattered in the ileum, to be stimulated to secrete by transit of glucose and triglyceride in the jejunum[23]. Secretory cells of NT are observed in the ileum, and NT decrease the movement of the small intestine. Its physiological action increase with the intake of lipids. ROSELL[20] reported that an increase of plasma NT following oral loading of three major nutritional elements, was largest with lipid emulsion. Secretory cells of VIP are distributed through out the entire GI tract, and VIP is considered to work as neurotransmitters in the small intestine, causing vasodilation at the time of absorption[9]. In our study, too, ED was directly infused into the jejunum, and glucose, the main component of ED, stimulated and increased EG secretion. But because ED contained only a small amount of lipid, NT did not increase as remarkably as EG[3].

2. Colonic surgery and elemental diet

In order to improve the outcome of colonic surgery, prevention of local complications occurring soon after an operation, such as leakage, etc. is necessary. It is desirable to obtain an ideal preoperative bowel preparation while an oral diet is taken. Results with mechanical preparation

such as laxative administration or the use of enema often depend on the degree of stenosis in the colonic cavity which ultimately results in poor treatment. With the method using modified ED, mainly consisting of ED, fecal volume obviously decreases, thus improving the state of nutrition. The period of preoperative bowel preparation is mostly 3–5 days in cases without stenosis. While in cases with stenosis, an appropriate administration pericd can be found with the formula noted above. It seems that the longest period should be 8 days in cases with severe stenosis[22].

Treatment of low output fistula has been conducted utilizing characteristic of ED that does not stimulate digestive juice secretion. We also succeeded with a treatment in 4 cases of low output fistula[4]. ED is also effective on the bowel rest and maintenance of nutritional state of the patients with acute deteriorating period of inflammatory intestinal diseases, particularly, CROHN's disease[5]. VOITK[24] reported that ED had improved the nutritional state of some patients with CROHN's disease. AXELSSON[6] reported that remission was attained in 8 out of 11 cases by the administration of ED, and that ED was very effective as a primary therapy for this pathological condition. For the treatment of CROHN's disease, a daily supplement of nutrition is important and home enteral hyperalimentation and pharmacotherapy are considered effective measures toward this end.

3. Elemental diet and intestinal bacteria

ED administration is reported to reduce intestinal microflora. WINITZ[26] offered two reason; since nutritional elements are completely absorbed in the small intestine, intestinal bacteria transform to a fasting condition, and living environments for bacteria are reduced because of decreased fecal volume. BOUNOUS[7], however, reported that, though no changes were seen in total colony number, enterococci were reduced significantly.

GLOTZER[11] reported that while aerobes and enterococci decreased with a 2–4 day use, no marked changes appeared with 5-day use. JOHNSON[13] mentioned that coliform, bacteroides and enterococci decreased with a 5-day administration. In our study, long-term administration of ED in rats did not cause changes in total colony number in the colon, and aerobes showed a larger decrease than anaerobes. With these changes in intestinal microflora, prothrombin time elongated and hemorrhagic tendency in various organs appeared[14], suggesting the deficiency of vitamin K in vivo. The above data also suggest the possibility of the same phenomena occurring in clinical use.

Conclusion

We used ED before and after gastrointestinal surgery and made experimental studies on changes in intestinal microflora following ED administration. The following results were obtained:

1) With enteral feeding administered after upper GI surgery, changes in bowel movement and abdominal symptoms appeared in about 70% of the cases, and plasma levels of EG and NT increased.

2) When ED was used as a preoperative bowel preparation for colonic surgery, the preparation

was found to be poor in 19% of the cases having clinical symptoms of stenosis. 31% of the cases with a index of stenosis greater than 50% based on the barium enema, but adequate for other cases.

3) As a results of giving ED to rats over a prolonged period, the ratio of anaerobes/aerobes increased, causing changes in microflora. This prolonged prothrombin time, and hemorrhagic diathesis was observed, but this hemorrhagic tendency improved after the administration of vitamin K.

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和文抄録

消化器外科における成分栄養法

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1976年経腸的高カロリー栄養法の概念が確立されてから，経腸栄養法は TPN と同様の臨床効果が得られるようになった．私達も消化器手術の術前・術後に elemental diet (ED) を用い，また，実験的に ED 投与時の消化管各部位の細菌叢の変化について検討し，以下の結果を得た．1)上部消化管術後に経腸栄養を行うと便の性状の変化，腹部症状などが約70%に出現し，血中 enteroglucagon, neurotensin が有意 ($p<0.05$) に上昇した．2)大腸手術の術前腸管処置に ED を用いたところ，狭窄症状を有した例の19%，注腸X線像で狭窄度が50%以上の症例の31%が腸管処置が不良で，他は良好な結果が得られた．3)ラットに ED を長期間投与したところ，嫌気性菌／好気性菌の比率が増加し，消化管各部位で細菌叢は著しく乱れた．その結果プロトロンビン時間は延長し出血傾向が出現したが，ビタミンKの投与で回復した．